



The Generation IV Roadmap Project

***Dr. Ralph G. Bennett, Director
Advanced Nuclear Energy, INEEL***

***ANS President's Session on Advanced Reactor Programs
June 11, 2002***

The Gen IV Technology Roadmap

- ***Describes systems deployable by 2030 or earlier***
- ***Determines which systems offer significant advances towards:***
 - ***Sustainability***
 - ***Safety and reliability***
 - ***Economics***
- ***Integrates long-term R&D for nuclear technology***
- ***Plans for a Generation IV R&D program***

The Two-year Roadmap in Brief

The First Year: Preparations and Study

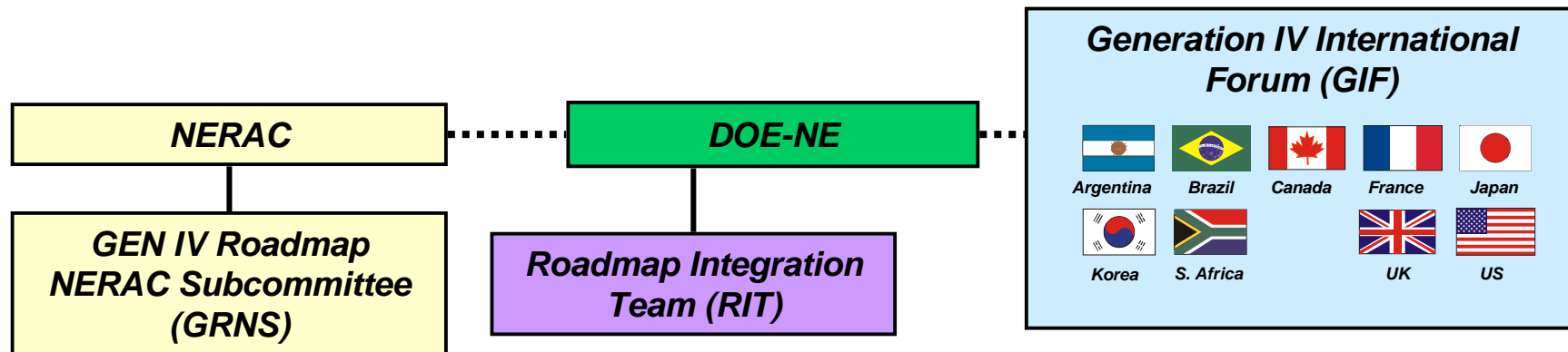
- ***Derive technology goals based on industry needs***
- ***Plan and organize the activity***
- ***Determine how to measure concepts against goals***
- ***Identify concepts for evaluation***
- ***Detail the most promising concepts***

The Second Year: Evaluate & Assemble

- ***Evaluate and determine the most promising concepts***
- ***Assemble a roadmap for R&D to support them***

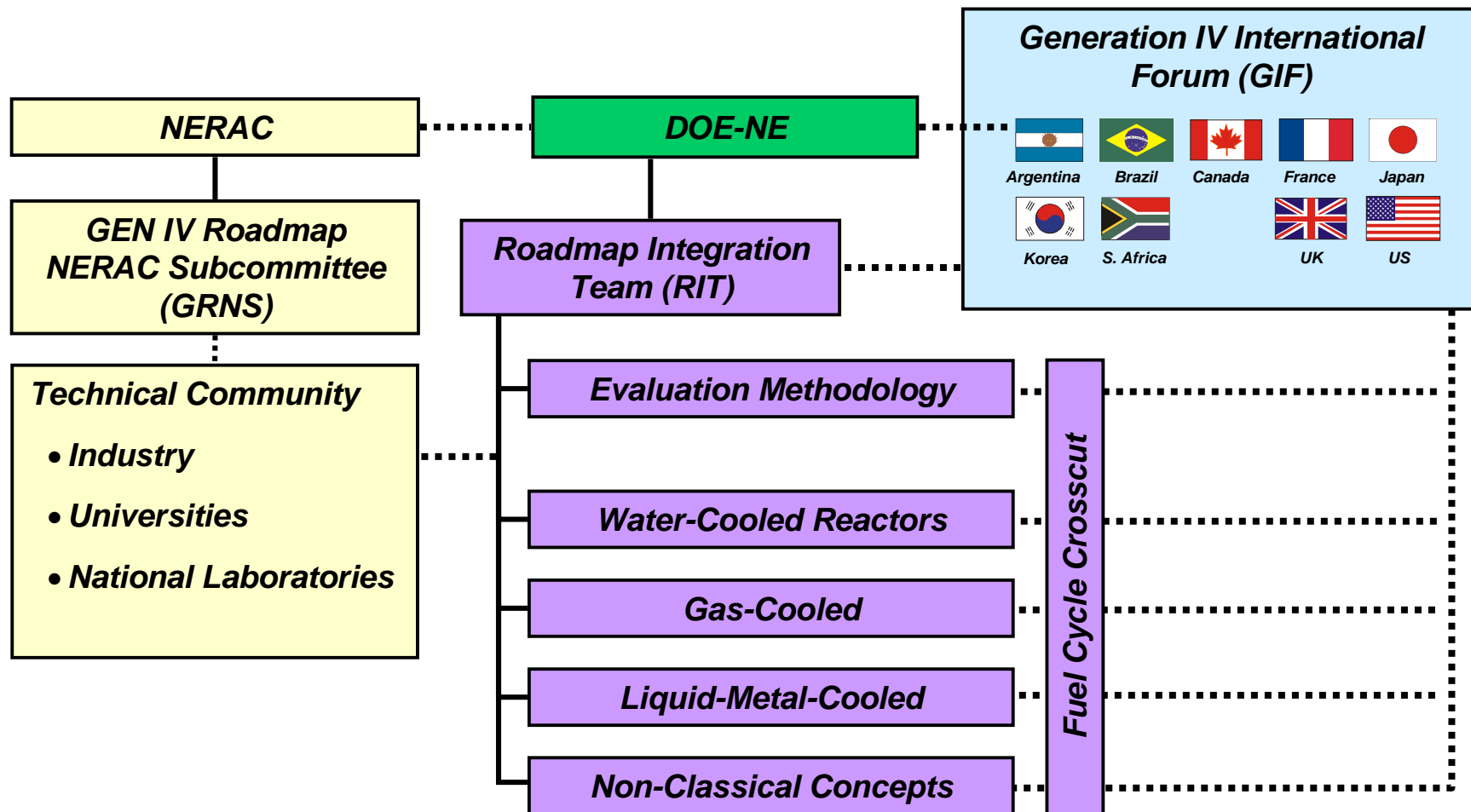
Organizational Evolution – 1

- Jan 2000 First Meeting of 9 Countries on Generation IV
- Sep 2000 Creation of NERAC Subcommittee



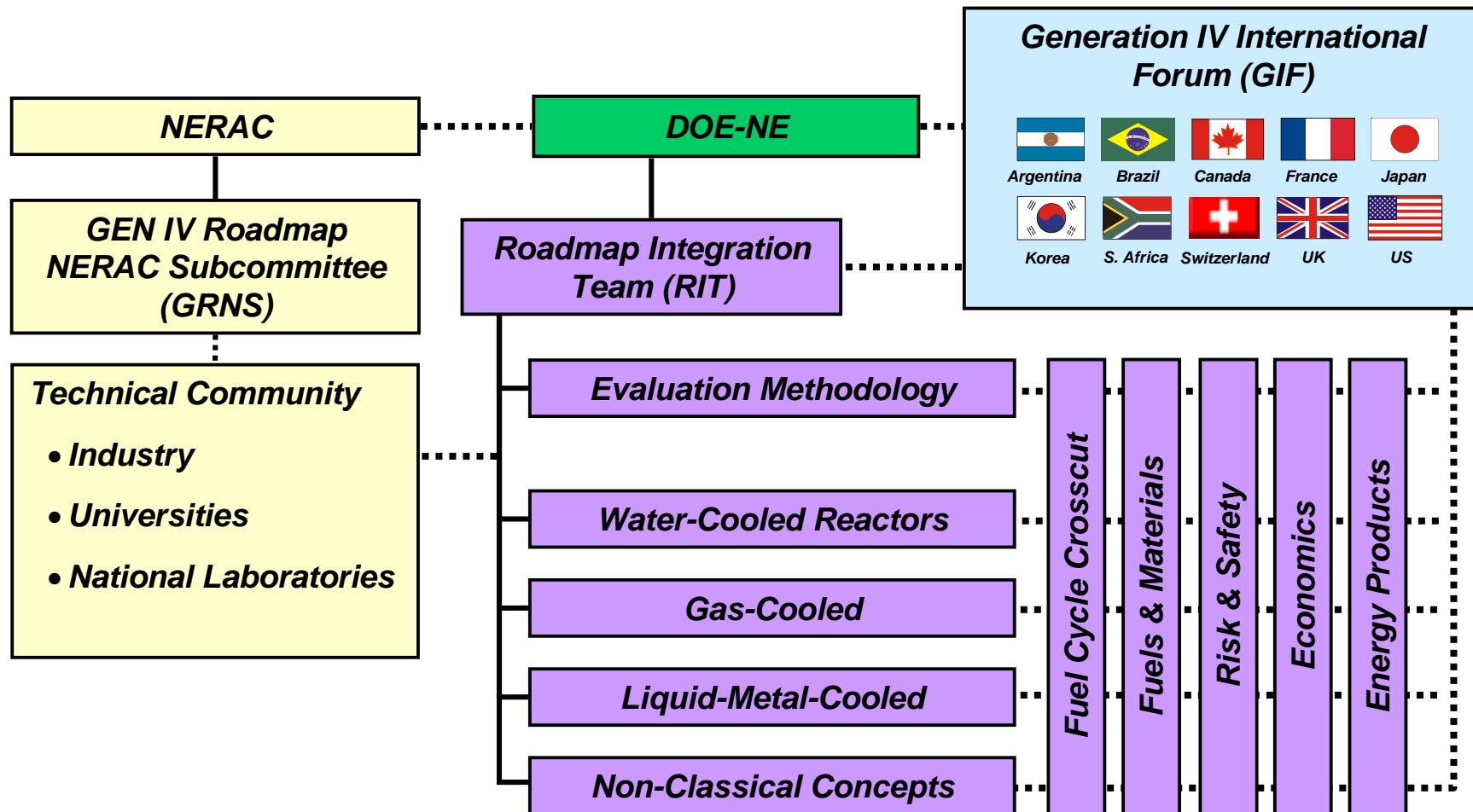
Organizational Evolution – 2

- Dec 2000 Creation of Working Groups and Fuel Cycle Crosscut
- Mar 2001 Incorporation of International Membership



Organizational Evolution – 3

- Sep 2001 Organization of Crosscut Groups
- Feb 2002 Switzerland joins the GIF



Generation IV International Forum

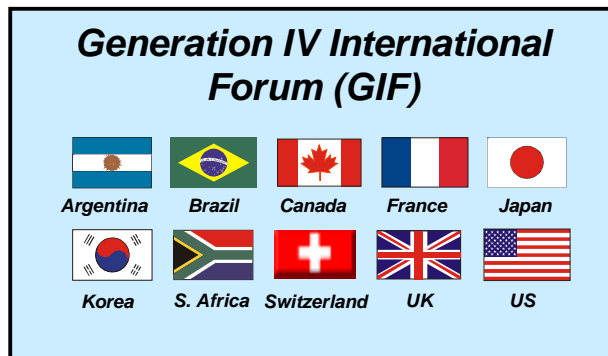
Charter signed in July 2001 to:

- ***Identify potential areas of multilateral collaborations on Generation IV nuclear energy systems,***
- ***Foster collaborative R&D projects,***
- ***Establish guidelines for the collaborations and reporting of their results, and***
- ***Regularly review the progress and make recommendations on the direction of collaborative R&D projects***

Roles of the GIF:

- ***Sponsors over 50 staff on the roadmap***
- ***Reviews high-level documents and brings an international perspective***
- ***Collaborates on Generation IV R&D***

GIF Progress



January 2000

Washington

Countries support Gen IV idea

April 2000

Washington

Experts convened on path forward

August 2000

Seoul

Comment on goals, write charter

March 2001

Paris

Finalize charter, support roadmap

October 2001

Miami

Comment on methodology

February 2002

London

Discuss concepts and selection

April 2002

Washington

Review concept evaluations

May 2002

Paris

Agree on 6 long-term concepts

July 2002

Rio de Janeiro

Review R&D plans

November 2002

Tokyo

Plan R&D collaborations

Concept Evaluation

Broad Request for Information (Apr 2001)

- ***Over 100 ideas submitted, about 1/3 international***

Qualitative Screening (Sep 2001)

- ***Qualitative criteria for each Gen IV goal***
- ***Many ideas combined, a few did not advance***

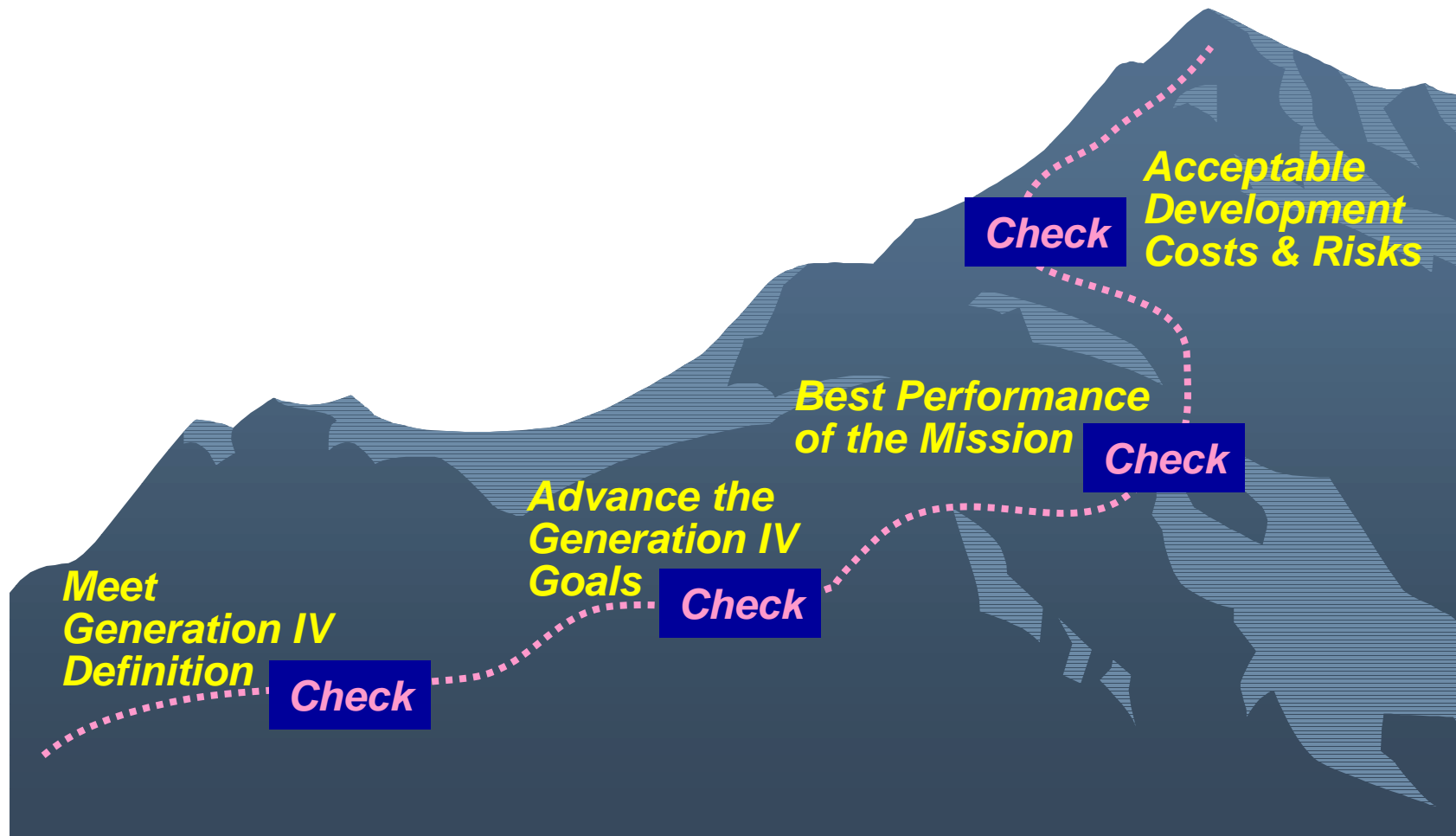
Quantitative Evaluation (Mar 2002)

- ***Quantitative criteria and metrics***
- ***Further refinement into 19 concepts***

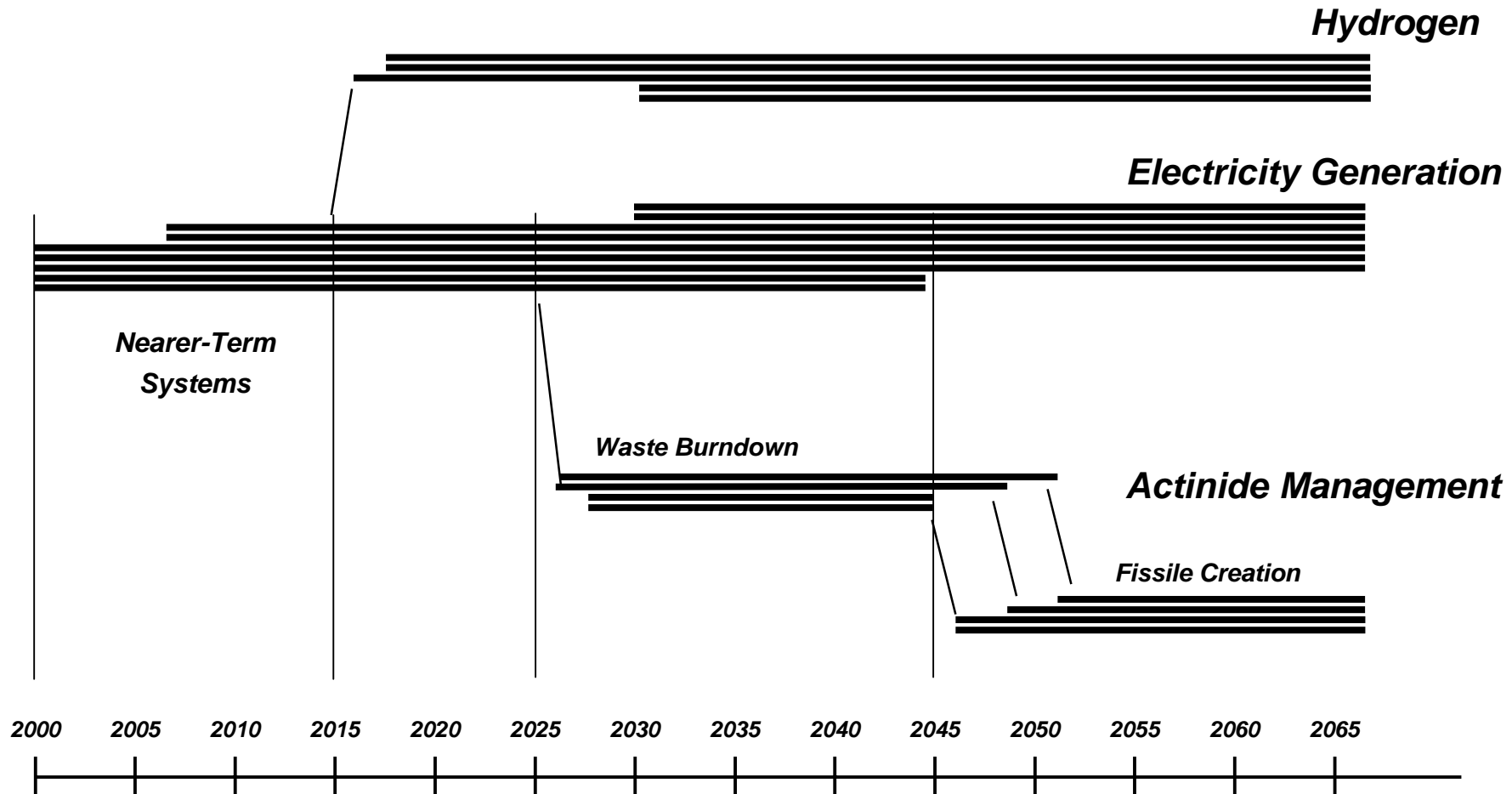
Selection of Most Promising Long-term Systems

- ***Discussed at the February, April & May GIF meetings***

Selecting the Most Promising Concepts



Important Missions for Generation IV



Highlights of System Concept Strengths

Sustainability

- *Closed cycle fast-spectrum systems*
 - *Reduced waste heat and radiotoxicity*
 - *Optimal use of repository capacity*
 - *Resource extension via regeneration of fissile material*

Safety and Reliability

- *Many concepts make good advances*

Economics

- *Water- and gas-cooled concepts*
 - *High thermal efficiency*
 - *Simplified balance of plant*
 - *Large and small plant size*

Hydrogen production and high-temperature applications

- *Very high temperature gas-, and lead alloy-cooled reactors*

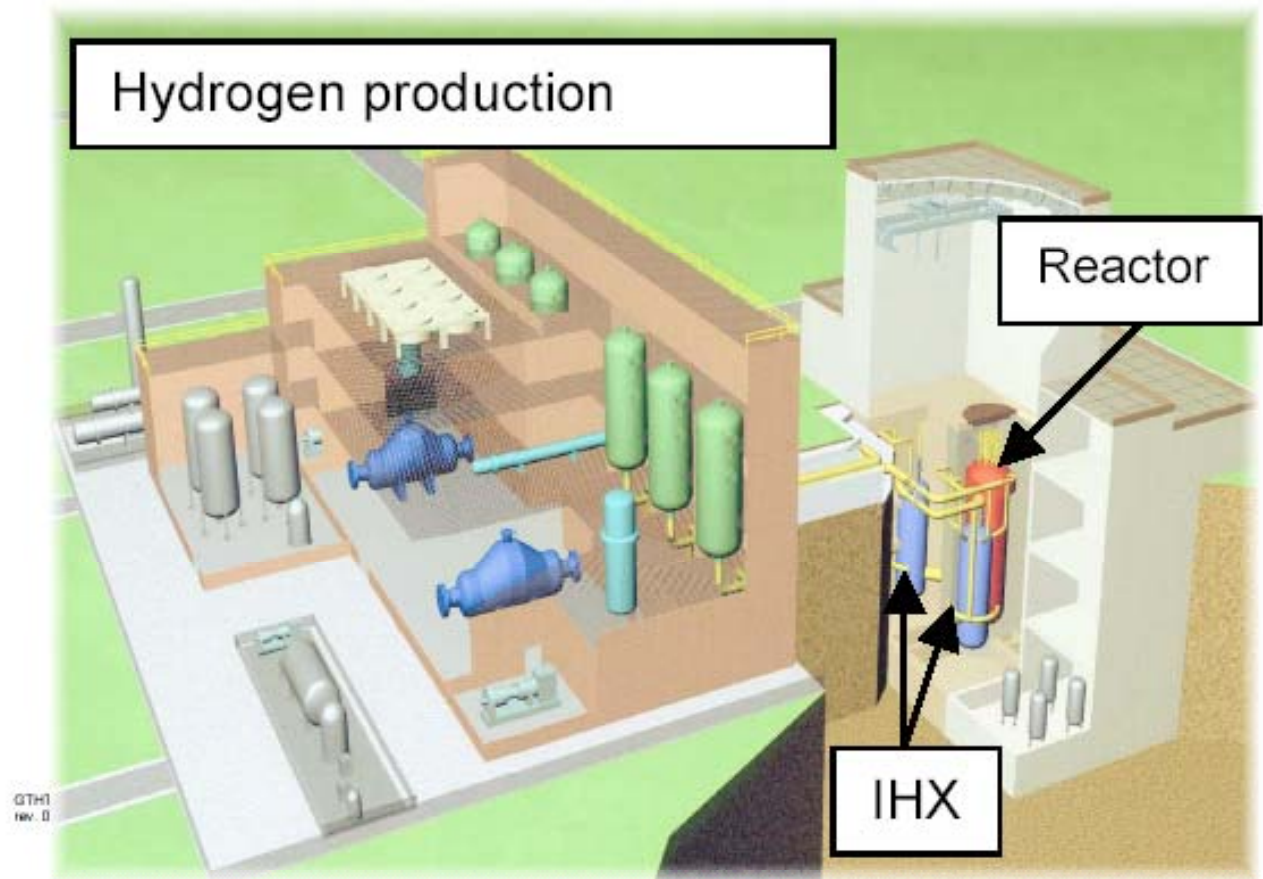
Very High-Temperature Reactor (VHTR)

Characteristics

- He coolant
- $>1000^{\circ}\text{C}$ outlet temperature
- 600 MWe
- Solid graphite block core based on GT-MHR

Benefits

- High thermal efficiency
- Hydrogen production
- Process heat applications
- High degree of passive safety



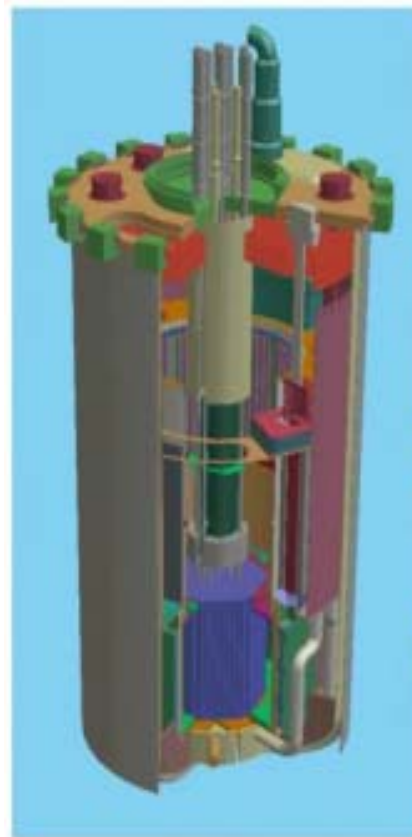
Sodium Liquid Metal-Cooled Reactor (Na LMR)

Characteristics

- Sodium coolant
- 150 to 500 MWe
- Metal fuel with pyro processing / MOX fuel with advanced aqueous

Benefits

- Consumption of LWR actinides
- Efficient fissile material generation



Liquid Metal Reactor
Actinide Recycle
System



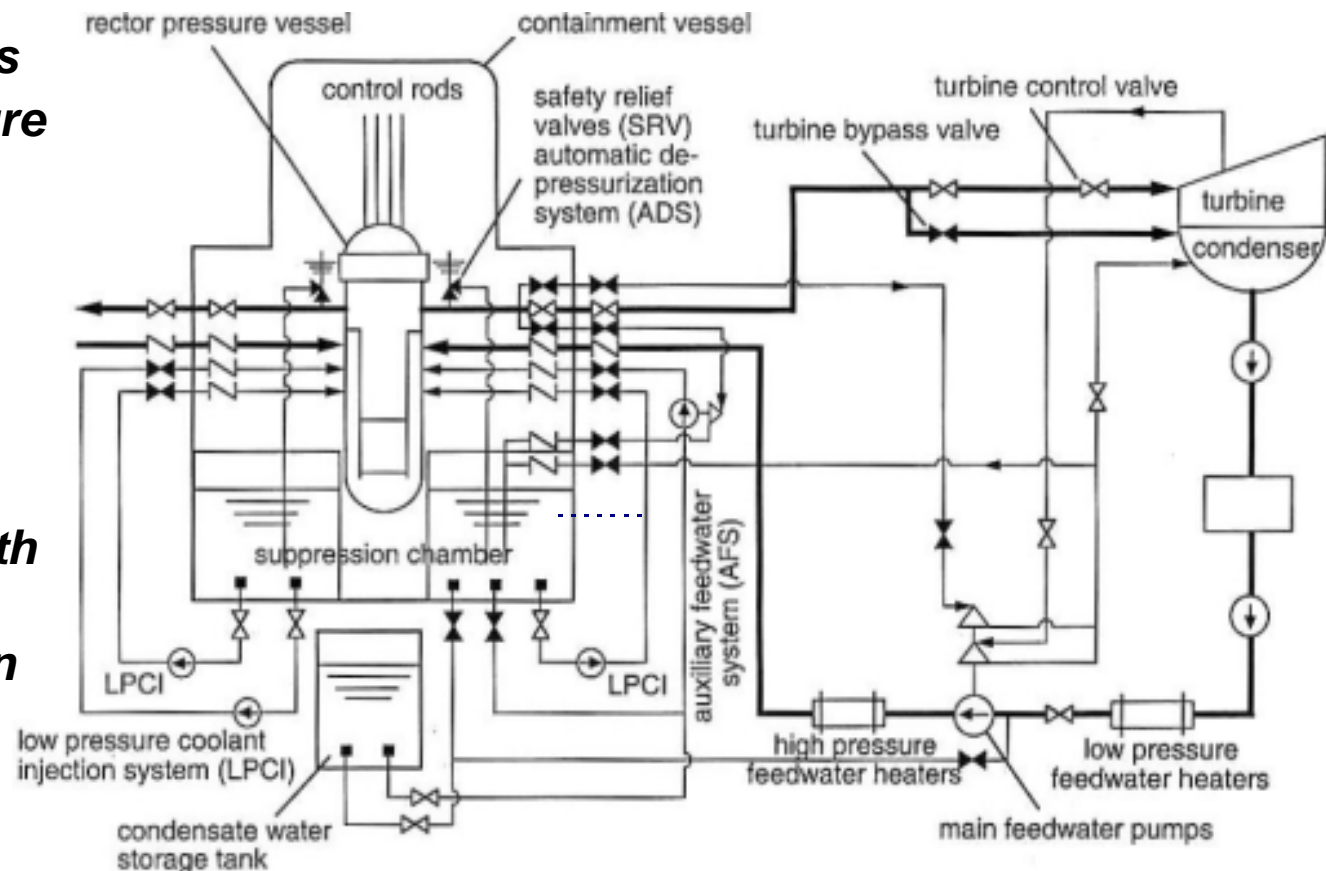
Supercritical Water Reactor (SCWR)

Characteristics

- **Water coolant at supercritical conditions**
- **500°C outlet temperature**
- **1700 MWe**
- **Simplified balance of plant**

Benefits

- **Efficiency near 45% with excellent economics**
- **Thermal or fast neutron spectrum**



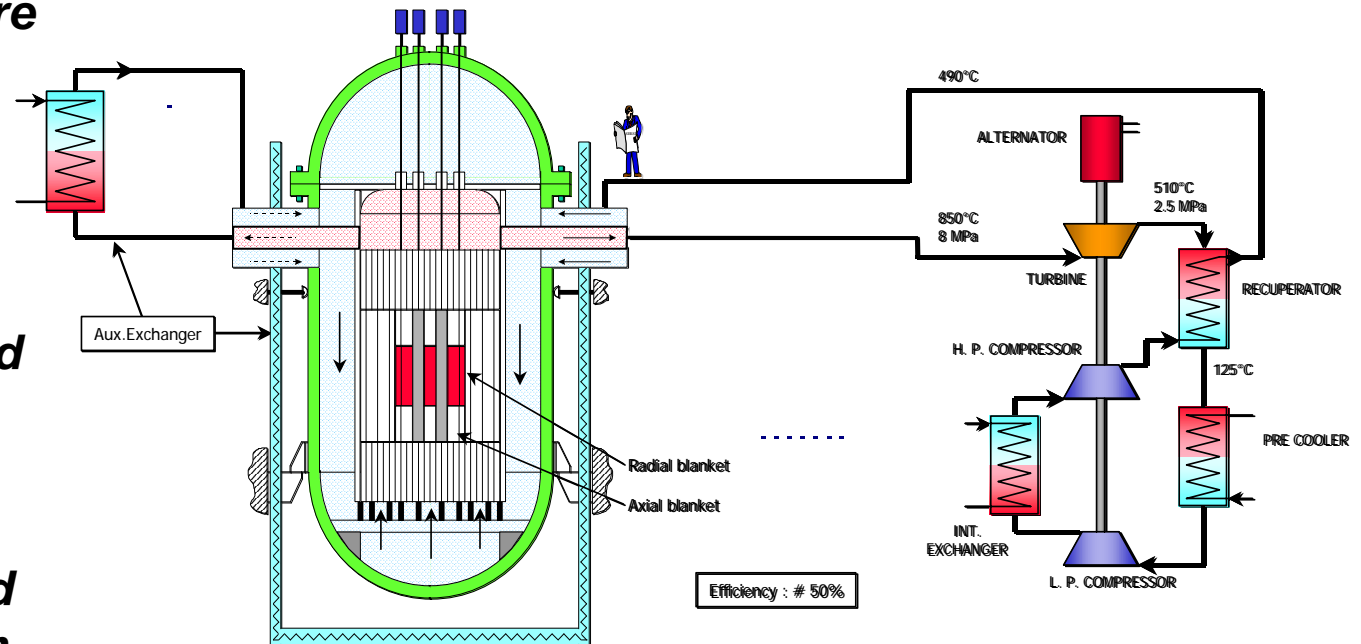
Gas-Cooled Fast Reactor (GFR)

Characteristics

- He coolant
- 850°C outlet temperature
- direct gas-turbine conversion cycle – 48% efficiency
- 600 MW_{th}/288 MW_e
- Several fuel options and core configurations

Benefits

- Waste minimization and efficient use of uranium resources



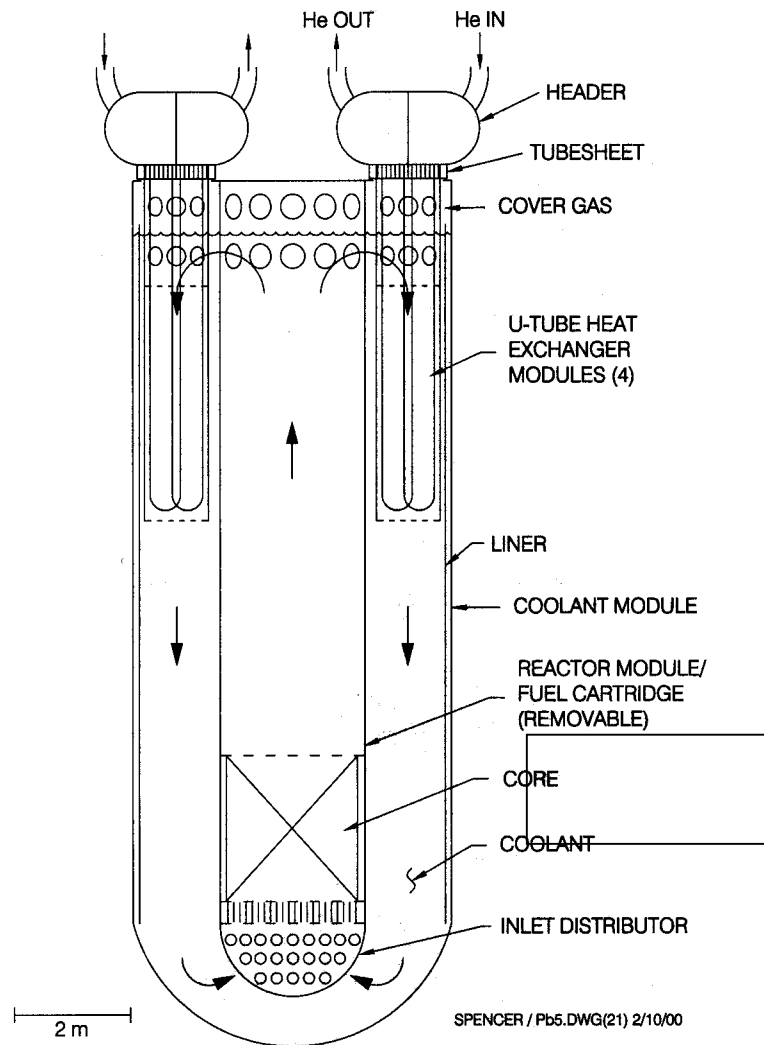
Pb/Bi Reactor – Cartridge Core (Pb/Bi Battery)

Characteristics

- ***Pb or Pb/Bi coolant***
- ***540°C to 750°C outlet temperature***
- ***120-400 MWe***
- ***15-30 year core life***

Benefits

- ***Distributed electricity generation***
- ***Hydrogen and potable water***
- ***Cartridge core for regional fuel processing***
- ***High degree of passive safety***
- ***Proliferation resistance through long-life cartridge core***



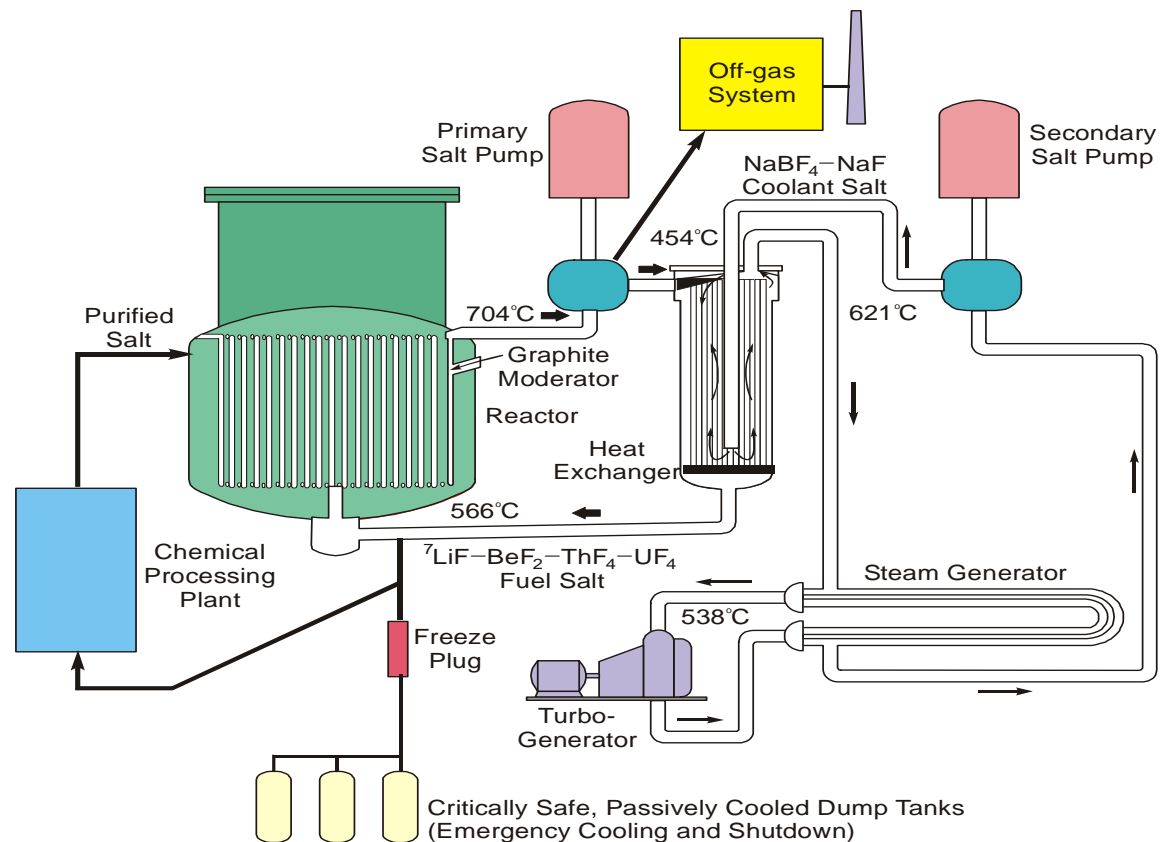
Molten Salt Reactor (MSR)

Characteristics

- **Fuel: liquid Li, Be, Th and U fluorides**
- **700°C outlet temperature**
- **1000 MWe**
- **Low pressure (<0.5 MPa) & high temperature (>700°C)**

Benefits

- **Low source term due to online processing**
- **Waste minimization and efficient use of uranium resources**
- **Proliferation resistance through low fissile material inventory**



Roadmap Documentation

Roadmap Summary

- ***Sets the context and summarizes recommendations***
- ***Written for non-technical audience***

Technical Roadmap

- ***Provides additional technical descriptions, analysis, and justifications***
- ***Written for nuclear technical audience***

Detailed Roadmap Reports

- ***Eventually available on CD-ROM***

Summary

- ***The roadmap is a two-year project, to be completed at the end of FY-02 and transmitted to NERAC***
- ***There is significant international participation by the 10 countries in the Generation IV International Forum***
- ***Nearly 100 international experts staff the working groups, with significant industrial participation***
- ***The primary objective of the Roadmap is to define an overall R&D plan to advance the next generation***
- ***International collaborative R&D will be based on the R&D plan***